APPENDIX A

ACCOUNTABILITY DATA RELATED TO THE 1957 FIRE AND TO EARLY OPERATIONS IN BUILDING 71

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This appendix first describes the plutonium accountability data related to the 1957 fire and its limitations. Section A.2 discusses the main difficulty with early accountability data, which is the lack of reliable information on the amounts of plutonium in solid wastes. The amounts of "material unaccounted for" in early years of operation are also discussed in Section A.2. References are listed in Section A.3.

A.1 ACCOUNTABILITY DATA FOR THE 1957 FIRE

One of our first goals while searching through the classified records at Rocky Flats was to identify information on plutonium accountability for the September 1957 fire. The search was successful. Records of the plutonium loss for the 1957 fire were found in monthly accountability reports prepared between the time of the fire and completion of the final cleanup of Room 180 several years later. We requested the declassification of notes taken while reviewing the 1957 fire data and of documents containing the accountability data. The U.S. Department of Energy (DOE) declassified and released information regarding the plutonium accounting for the 1957 fire, together with information on plant inventory differences at Rocky Flats (DOE 1994). Our notes taken during review of classified accountability documents were also declassified in March 1995.

The DOE press release referenced above relies upon an analysis in Zodtner and Rogers (1964) of plutonium losses during the first 11years of operation. Their summary of data for the 1957 fire, shown in Table A-1, leads to an estimated fire loss of nearly 6 kg of plutonium. It also indicates that about 29.9 kg of plutonium metal items was not damaged in the fire.

Table A-1. Accountability Data for 1957 Fire (Zodtner and Rogers 1964)

Description	Amounts of Pu (g)	
Inventory in Room 180 before fire		62,515
Undamaged items removed	29,857	
Recovery through processing	24,356	
Measured discard	2,315	
Total recovered		56,528
Fire loss		5,987

There are some small numerical differences between the table in Zodtner and Rogers (1964) and our review of earlier accountability documents. This is not surprising because initial estimates in a monthly report could have been revised to reflect the results of analyses that were

not available at the time the report was written. These minor differences are not important and cannot be investigated in detail because only summary data are still available.

Declassified information that was obtained from accountability reports prepared in the fall of 1957 is presented in Table A-2. The differences between the October and November reports reflect a better accounting of the material present and previously unrecorded removals of some metal parts from the fire area. The November accounting indicates that about 9 kg (the sum of 4.9, 2.3, and 2.0 kg) of plutonium was involved in the fire. The status of the 15.9 kg of plutonium that was located in the room but not immediately recovered is not clear from the report.

Table A-2. Accountability Data for Building 71 Fire from 1957 Reports

	Amounts of Pu (kg)	
Description	Oct 1957 report	Nov 1957 report
Pre-fire inventory	56.4	62.5
Recovered	29.9	37.3
Located in room	15.9	15.9
Believed present, but not located	6.3	4.9
Measured loss (written off)	2.3	2.3
Unaccounted for (written off)	2.0	2.0
Post-fire totals	56.4	62.4

A comparison of Tables A-1 and A-2 reveals a difference in the description of one item in the list. According to our investigation, the quantity called “measured discard” in Table A-1 was in fact the total mass of plutonium items that were removed from the inventory (written off). It is not clear whether any of the items was subsequently located, but the 2.3-kg write off persisted in the accountability reports. As Room 180 was cleaned up in 1960 and 1961, measurable amounts of plutonium that were removed were deducted from the room inventory. When cleanup was completed, the account was closed with slightly more than 4 kg still unaccounted for. This quantity and the 2 kg in the last line of Table A-2 agree with the 6-kg fire loss shown in Table A-1. However, the other 1957 write off of 2.3 kg of plutonium appears to be in the same category. This means that the amount of plutonium that was not recovered after the fire was probably 8.3 kg, rather than the 6 kg that has been reported.

The primary reason why as much as 13% of the pre-fire inventory was declared “lost” is that there were no reliable measurements of plutonium in solid wastes. The failure to provide an adequate accounting of plutonium in solid wastes during the early years of Rocky Flats operations, including the post-fire cleanup period, is discussed in the next section.

A.2 INFORMATION ABOUT SOLID WASTE DISPOSAL AND MATERIAL UNACCOUNTED FOR AT ROCKY FLATS

Early routine waste disposal reports contained data on concentrations and amounts of radioactivity in liquid wastes, but the information about solid wastes is limited to numbers of containers and the corresponding volumes and gross weights of material shipped (Farrell 1957). Thompson (1969) gives annual data on numbers of containers and waste volumes, but only summary data on the radionuclide content were included. For the 6 years 1954–1959 and the decade 1960–1969, Thompson reported that about 17.4 and 283 kg of plutonium, respectively, were shipped to Idaho. Lee (1971) provided estimates of the annual amounts of plutonium shipped to Idaho. His total for the 1954–1959 period agrees with that given by Thompson, but his total for the 1960s is greater by 40 kg. Values reported by Lee for each calendar year from 1954 through 1961, the last year of fire cleanup work, are presented in Table A-3.

Table A-3. Estimates of Plutonium Mass in Wastes Shipped to Idaho and of Plutonium That Was Unaccounted for at Rocky Flats

	Pu in waste shipped to Idaho		
Calendar year	Originally reported (kg)[a]	1994 estimate (kg)[b]	Plutonium mass (kg) unaccounted for[c]
1953	[d]	[d]	0.07
1954	0.26	1.6	3.9
1955	1.6	8.0	15.5
1956	2.4	16.1	26.7
1957	3.4	23.3	35.3
1958	4.6	54.1	103
1959	5.1	59.4	98.9
1954–1959	17.4	162.5	283.4
1960	3.8	70.3	72.0
1961	5.9	64.3	97.7
1954–1961	27.1	297.1	453.1

[a] Estimates from Lee (1971).
[b] Estimates from EG&G (1994).
[c] Material unaccounted for (MUF) for plutonium from Zodtner and Rogers (1964).
[d] Waste shipments to Idaho began in 1954.

Table A-3 includes the more recent best estimates made by staff at the Idaho National Engineering Laboratory (INEL) in consultation with Rocky Flats personnel (EG&G 1994). The newer estimates are substantially higher than those given by Lee (1971). For example, the sum of shipments for years 1954–1959 is 162 kg, roughly 9 times higher than the amount reported by

Lee (1971). These estimates from the EG&G (1994) report are the basis for the current opinion that much of the plutonium previously considered unaccounted for was in fact shipped as waste.

It is difficult to measure the amount of plutonium inside a drum of solid waste. Barrels of process line wastes from Building 71 typically weighed more than 50 kg apiece, and weights of those full of sludges from Building 74 exceeded 200 kg each. In the early years, radiation levels outside the drums were measured with a beta-gamma survey meter when wastes were shipped, but there was no serious attempt to measure plutonium mass. The isotopes of interest (^{239}Pu and ^{240}Pu) are primarily alpha-emitters. The alpha particles are readily absorbed and cannot be detected when the plutonium is mixed in a mass of other material. Both ^{239}Pu and ^{240}Pu also emit weak x-rays, with energies between 12 and 20 keV, following about 6% of the alpha-particle emissions. However, these x-rays are strongly attenuated by material in the drum and by the steel walls of the drum. Six inches (15 cm) of light material (paper, rags, etc.) packed to a density of 0.24 g cm^{-3} (corresponding to 50 kg in 208 L) attenuates 12-keV x-rays by a factor of about 8000 and 20-keV x-rays by a factor of about 12. For 20-keV x-rays, a 0.25-cm iron barrel wall would provide an additional attenuation factor of about 30.

Americium-241, produced by decay of ^{241}Pu, is more easily detected by external survey of a barrel. Americium-241 emits 60-keV gamma rays following about 36% of its alpha-particle emissions and 12- to 20-keV x-rays about 64% of the time. The x-ray and gamma ray emissions from ^{237}U, also produced by decay of ^{241}Pu, are similar to those of ^{241}Am. For wastes shipped 2 years after separation of the plutonium, the ^{237}U would contribute about 25% of the energetic photon emissions from barrel. For the 60-keV photons, a 0.25-cm iron barrel wall would provide an attenuation factor of about 6 and a 15-cm layer of compacted paper and rags would reduce the intensity by about a factor of 2. These are only illustrative calculations. Actual barrels of waste contained an array of other materials (including metal and wood, for example) that could substantially affect the radiation level measured at the surface of the container. While the radiations from ^{241}Am and ^{237}U are more likely to be detected, survey meter readings did not provide a reliable way to estimate the plutonium content of a barrel.

The number of drums of waste shipped to Idaho was so large that overlooking small quantities in each drum could easily lead to large imbalances in the plutonium accounting system. The monthly average number of waste drums shipped from Buildings 71 and 74 increased from 200 in 1954 to 300 in 1956. The shipping rate increased to 400 drums per month in 1957, when two major accidents occurred, and then dropped back to 300 drums per month the following year.

Serious attempts to measure the amounts of plutonium in drums and boxes of solid waste that were shipped to Idaho did not begin until after the analysis of plutonium losses by Zodtner and Rogers (1964). A few years later, most (~ 80%) of the drums of plutonium waste shipped from Buildings 71, 74, 76, and 77 were analyzed using the barrel counter (Ziegler 1967). However, there were still relatively large uncertainties associated with the technique. In a status report on the 1969 fire area material balance, Dompierre (1970) states that the neutron counting technique had an estimated accuracy (sic) of ±25%.

Most of the estimates of material unaccounted for (MUF) that led to the investigation by Zodtner and Rogers (1964) are given in Table A-3 by calendar year. The tabulated values were compiled from the quarterly data in their report. The annual MUF grew rapidly in the early years, presumably corresponding to an expansion of operations, to about 35 kg in 1957. The cumulative amount near the time of the fire (as of the end of September 1957) was 68.9 kg. The amount of MUF in 1958 was about triple that in 1957, and the annual MUF averaged about 100 kg for the

next several years. Any write off of material from the 1957 fire plutonium accountability ledger during these years were minor perturbations in annual MUF estimates. Amounts for calendar year 1962 and the first half of 1963 were 124 kg and 86.7 kg, respectively. The total MUF of 664 kg, at the end of fiscal year 1963, was certainly high enough to inspire an investigation.

Zodtner and Rogers (1964) identified several possible flaws in the plutonium accounting system that could contribute to the amount labeled "unaccounted for." These included: failure to consider radioactive decay of material in process and while away from the plant, measurement problems in liquids containing plutonium particles that were transferred to Building 74 for processing, holdup of material in prefilters and ducts that was not assessed routinely, and failure to account for plutonium in various solid wastes. The failure to account for plutonium in solid wastes was found to be the most important of the problems in the accountability system at that time. Zodtner and Rogers (1964) estimated that it had led to inventory differences of about 440 kg. Although some of the estimates made by Zodtner and Rogers were highly uncertain, their investigation shed substantial light on the question of plutonium MUF at Rocky Flats. Their findings led plant staff to develop improved techniques for routine measurements of plutonium in solid wastes.

A.3 REFERENCES

DOE (U.S. Department of Energy). 1994. *Openness Press Conference Fact Sheets*.

Dompierre, C.H. 1970. The Dow Chemical Company. Letter to R. E. Abbott, Rocky Flats Area Office, U. S. Atomic Energy Commission. Subject: Fire Area Material Balance. Declassified document, formerly CD70-9807. 8 December.

EG&G (EG&G Idaho, Inc.). 1994. *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952–1983*, EGG-WM-10903, Volume 1. Idaho National Engineering Laboratory.

Farrell, L.C. 1957. *History Report—Month, 1957—Waste Disposal Coordination Group*. Monthly internal letter reports. The Dow Chemical Company.

Lee, W.H. 1971. The Dow Chemical Company. Letter to Harvey F. Soule, U.S. Atomic Energry Commission. Subject: Rocky Flats Solid Waste Shipped to NRTS. 10 June

Thompson, M.A. 1969. The Dow Chemical Company. Letter to Bruce Schmalz, Idaho Operations Office, U.S. Atomic Energy Commission. Subject: Waste Disposal. 4 December.

Ziegler, D.L. 1967. *Survey of Plutonium Waste Discards. Deleted Version of Rocky Flats*. Deleted version of Rocky Flats classified Document CD67-5259. The Dow Chemical Company.

Zodtner, L.L. and R.F. Rogers. 1964. *Study of Unaccounted for Plutonium Losses*. Deleted version of Rocky Flats classified document CD64-130. The Dow Chemical Company.